MAINTAINABILITY DEMONSTRATION SPECIFICATION for the MAIN BATTLE TANK (MBT-70)

A SPECIAL PROJECT

VERNON O. CHANCE

Prepared for the Industrial Engineering Department
of Texas A&M University
in partial fulfillment of requirements for the degree
MASTER OF ENGINEERING
in
Industrial Engineering
January 1968

TABLE OF CONTENTS

Unclassified

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)*

USAMC Intern Training Center - USALMC
Red River Army Depot ATTN: AMXMC-ITC-E-M
Texarkana, Texas 75501

2a. REPORT SECURITY CLASSIFICATION

Unclassified

2b. GROUP

N/A

3. REPORT TITLE

MAINTAINABILITY DEMONSTRATION SPECIFICATION FOR THE MAIN BATTLE TANK (MBT-70).

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

N/A

5. AUTHOR(S) *(First name, middle initial, last name)*

Vernon O. Chance

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
January 1968	74	12

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
N/A	N/A
b. PROJECT NO.	
c.	9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*
d.	N/A

10. DISTRIBUTION STATEMENT

Distribution of this document is unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
N/A	Dir, for Maintenance Hdqr. USAMC Washington, D. C. 20315

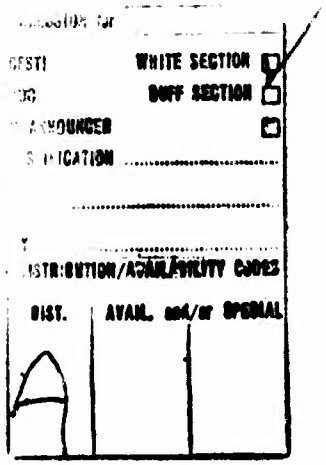
13. ABSTRACT

This report is an actual maintainability demonstration specification. The particular application is to the MBT-70; however, it is general in nature and should provide guidelines for specifications of this type. This report would be a good addendum to MIL-STD 471 as an example of interpretation of the specification and conversion to contract terms.

DD FORM 1 NOV 68 1473 REPLACES DD FORM 1473, 1 JAN 66, WHICH IS OBSOLETE FOR ARMY USE.

Unclassified

Security Classification



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INTRODUCTION

Until very recently each MILITARY SERVICE and COMMODITY COMMAND within each service had their own maintainability demonstration requirements. This has presented many problems to the contractor because each command had their own ideas of demonstrating maintainability. To provide unified M demonstration requirements, MIL-STD 471 was developed and replaced seven original specifications. It is pointed out there were several instances in which commands had no maintainability effort or specifications at all. Even though MIL-STD 471 has provided a common ground, it is very general in nature and leaves much to the interpretation. Also, the standard states that the demonstration specification shall be prepared by the contractor. A more realistic specification is possible if the procuring activity prepares the specification with the contractor providing the inputs; these inputs are to be reviewed by the procuring activity very closely.

At the request of the Joint Engineering Agency for M demonstration specification for the MBT-70 and as a project for Industrial Engineering 685, the specification contained in the following pages was prepared. The MBT-70, at the time of request, had just started into Advance Production Engineering Phase which meant the design was fairly firm. Some minor changes are possible at this phase. In addition to meeting the immediate need of a M demonstration for the

MBT-70, it is the author's intent that this specification will also provide a bases from which a standardized MIL specification will be developed for use throughout the Army and DOD.

It is felt that the state-of-the-art in maintainability is not advanced to where maintainability requirements can be expressed in quantitative terms only. Consequently, qualitative requirements were prepared in terms of questions which could be answered yes or no or not applicable. There are nine checklists covering visual displays and illumination, accessibility, identification, safety, servicing, cabling and connectors, test points, and equipment unit. Even this type of approach requires good engineering judgement. To ensure that qualified persons answer the questions, a biography is required on each individual and must be approved by the procuring activity before the person is considered qualified. A person can answer only questions in the area in which he is qualified and he is required to initial each question he answers.

The specification is divided into six sections and an appendix. First, second, and third sections contain the scope, reference sources, and definition of terms respectively. Section four makes up the test demonstration requirements. These requirements are broken down into the following areas:

1. Demonstration conditions
2. Demonstration maintenance and observer team

3. Demonstration support material
4. Pre-demonstration phase
5. Formal demonstration phase
6. Retest phase
7. Sample size requirements
8. Data requirements
9. Contractor organization and maintainability demonstration schedule

Section five consists of the test demonstration procedure and contains the following areas:

1. Sample size calculation
2. Maintenance task selection
3. Test method
4. Demonstration criteria

Data makes up section six and is composed of these areas:

1. Reports and data collection
2. Data reduction and analysis
3. Maintainability demonstration report

There are three appendices. The first two contain the quantitative apportionment, and qualitative checklists. The third appendix deals with the theory on which sample size equations are based. Also, the equations which determine acceptance/rejection of a task are explained.

1. SCOPE

1.1 General - This specification outlines the requirements and procedures for the maintainability test demonstration of the MBT-70 system. Statistical requirements contained herein are based on the normalized distribution.

1.2 Purpose - This specification provides the user with the following objectives:

(a) Insure that quantitative requirement in terms of $\overline{M}_{ct}$, $\overline{M}_{pt}$, and $\overline{M}$ are specified.

(b) Insure that qualitative features of the system and support material are assessed.

(c) Insure that a uniform demonstration test procedure is used.

(d) Insure that data collection, reduction, analysis, and reporting are standardized.

(e) Insure that criteria for acceptance/rejection of each task are formulated.

2. REFERENCE DOCUMENTS

2.1 The issue of the following document in effect on the date of invitation for bids forms a part of this standard to the extent specified herein: MIL-STD-721, Definition of Effectiveness Terms for Reliability, Maintainability, Human Factors and Safety.

2.2 The following documents are references used in preparing this specification. They are not a part of this specification, but are to be used for supplemental information only.

STANDARDS

MIL-STD-470	Maintainability Demonstration
MIL-STD-471	Maintainability Program Requirements
MIL-STD-1228	Maintainability Criteria for Tank-Automotive Materiel

SPECIFICATION

MIL-M-26512C(USAF) Maintainability Specification

PAMPHLET

AMCP 706-134 Maintainability Guide for Design

REGULATIONS

AR 700-51 Improved Management and Determination of Requirements for Procurement of Technical Data and Information

MICOM Regulation 702-1 Product Assurance

REPORTS

Cox, Charles D., Maintainability Engineering Guide; U S Army Missile Command Report No. RC-S-65-2, 1 October, 1965

Cumingham, C. E., and Rigby, L. U., Maintainability Demonstration Plans and Procedures, Ford Philco, Tech Meno No. 9, August, 1963

Cumingham, C. E., Maintainability Demonstration Results And Experience, Ford Philco, Western Div. Lab., Palto Alto, California, August, 1967

TEXTS

Dixon, Wilfrid J., and Massey, Frank J., Jr., Introduction to Statistical Analysis, New York, McGraw-Hill Book Co., 1957

Geise, John, and Holler, Walker W., Editors, Maintainability Engineering, Martin-Marietta Corp. and Duke University, Contract No. DA-31-124-ARO-D-100-34, 1965

3. DEFINITIONS

3.1 The definitions set forth in MIL-STD-721 shall apply to this specification. For the purpose of this specification, the following definitions shall apply.

3.1.1 Support material includes support equipment, tools, test equipment, technical publications and manuals, spares and consumables, safety equipment, etc.

3.1.2 Item - A generic term used to identify the specific entity under consideration. As such, it may be a part, sub-assembly, group, equipment, etc.

3.1.3 Maintainability demonstration - A test which demonstrates the degree of achievement of specified quantitative and qualitative maintainability (M) requirements.

3.1.4 Pre-demonstration phase - A period of time immediately prior to commencement of formal M demonstration during which the test team, facilities, and support material will be evaluated.

3.1.5 Formal demonstration phase - A period of time during which M demonstration tests are performed, data acquired and analyzed.

3.1.6 Retest phase - A period of time following a formal M demonstration for repeat or special tests.

3.1.7 Maintenance environment - The climatic and operational conditions under which an item will be maintained.

3.1.8 Scheduled maintenance - A specified period of time when preventive maintenance is performed on the system.

3.1.9 Unscheduled maintenance - Any corrective maintenance performed on the system during any period of time except during scheduled maintenance.

4. TEST DEMONSTRATION REQUIREMENTS

4.1 Demonstration Conditions

4.1.1 The MBT-70 system shall meet the following conditions:

(a) The system shall operate under the conditions specified in Mission Narrative MBT-70 No JDT-1083-C-66 for 6,000 miles or 600 hours between rebuild or depot overhauls. Mileage and hours shall begin when the system is released from the factory, ready for use. Mileage and hours shall end at 6,000 miles or 600 hours whichever occurs last, or when the system is retired.

(b) The system shall operate at least 1500 miles or 150 hours between performance of scheduled maintenance. Mileage and hours shall begin when the system is released from the factory, ready for use.

(c) The system shall operate without performance of scheduled and unscheduled maintenance or servicing per mission requirement of Mission Narrative MBT-70 No JDT-1083-C-66.

4.1.2 Quantitative requirements for the system shall be as follows:

(a) Total scheduled and unscheduled maintenance for the system shall not exceed 120 man-hours under operating conditions as specified in paragraph

4.1.1(a). Ninety (90) man-hours shall be apportioned to unscheduled maintenance (M_{ct}) and thirty (30) man-hours apportioned to scheduled maintenance (M_{pt}).

(b) Scheduled and unscheduled maintenance man-hours shall be apportioned per Appendix B for the MBT-70 sub-systems.

(c) Servicing time for this system shall not exceed the limit specified by the procuring activity.

4.1.3 A yes-no type of checklist shall be used to assess qualitative features of the system. The checklists shall be per Appendix A and demonstrated in accordance with paragraph 5.3.2.

4.1.4 The levels of maintenance to be demonstrated shall be as follows:

(a) Organization	First Echelon Second Echelon
(b) Field	Third Echelon

4.1.5 All scheduled and unscheduled maintenance, and servicing shall be demonstrated under extreme environmental conditions specified in paragraph 3.2.2.3, Page 45 of Mission Narrative MBT-70 No JDT-1083-C-66.

4.1.6 The demonstration site(s) shall be representative of actual field conditions. Support of the system shall be of the type and quantity expected in the operational

phase.

4.1.7 The selection of the items and the procedure to verify maintainability requirements shall be in accordance with paragraph 5.

4.1.8 Mode of operation, including configuration, shall be specified with each item selected to be demonstrated in accordance with paragraph 6.1.2(a).

4.1.9 Simulation of a fault for corrective maintenance task shall be accomplished by opening, shorting, or grounding circuits, or by inserting faulty parts in such a manner as to duplicate the syndromes arising from random natural failures.

4.2 Demonstration Maintenance and Observer Team

4.2.1 The demonstration observer team shall meet the following conditions:

(a) The observer team shall be comprised of at least four persons; one of whom shall be an expert in the electrical/electronic field; one of whom shall be an expert in the mechanical field; one of whom shall be an expert in the human engineering field; and one of whom shall be an expert in the maintenance field. Each member of the observer team shall be considered an expert in only one of the above fields. An expert shall be an individual who is considered to be knowledgeable in one of the above fields as related to

combat track systems.

(b) The observer team shall be thoroughly familiar with the forms, procedures, and demonstration test plan and schedule applicable to the system. Further, the team shall be familiar with the design and function of the item under test or evaluation; basic troubleshooting methods; maintenance practice; and maintainability principles, data and methodologies.

(c) Other qualified personnel shall be used when it is determined none of the present observer members are qualified in the area under question. These individuals shall be approved by the procuring activity prior to using their talents.

(d) A biography shall be prepared on each member of the observer team in accordance with paragraph 6.1.1(a). These biographies shall be submitted to the procuring activity for approval fifteen (15) days prior to the start of pre-demonstration phase. Disapproval of a biography disqualifies that individual from the observer team.

4.2.2 The demonstration maintenance team shall meet the following conditions:

(a) Personnel assigned to the maintenance team shall be of the type, number and skill level representative of the personnel who will perform maintenance

during the operational phase.

(b) A biography shall be prepared on each member of the maintenance team in accordance with paragraph 6.1.1(a). These biographies shall be submitted to the procuring activity for approval thirty (30) days prior to the start of formal demonstration testing. Disapproval of a biography disqualifies that individual from the maintenance team.

4.3 Demonstration support material

4.3.1 The tools, test equipment, service equipment, spares, safety equipment, technical manuals, and any other items needed for the maintainability demonstration shall be provided by the contractor.

4.3.2 Items to be furnished by the procuring activity shall be requested sufficiently in advance by the contractor to be available for the formal demonstration phase.

4.3.3 All items shall be provided in the type, quantity and quality representative of operational requirements.

4.3.4 Any deviations or changes from operational provisioning requirements during maintainability demonstration tests shall be recorded and compensated for. These deviations and changes shall be recorded in accordance with paragraph 6.1.2(a).

4.4 Pre-demonstration Phase - During this phase, the observer team shall evaluate the contractor as to his

adequacy of preparation for the formal maintainability demonstration phase.

4.4.1 As a minimum, the following items shall be evaluated:

(a) Representation of test site and facilities to field, environmental, and support conditions.

(b) Availability, assembly, checkout and preliminary validation of demonstration support material.

(c) Maintenance and observer team briefed on schedule for formal demonstration, duties and responsibilities of each individual.

(d) Qualifications, training, and experience of maintenance team personnel as compared to maintenance personnel in the field.

4.4.2 A pre-demonstration phase evaluation report shall be prepared in accordance with paragraph 6.1.1(b). This report shall be submitted to the procuring activity for approval at the completion of the predemonstration phase.

4.4.3 Areas that are determined to be inadequate shall be corrected by contractor before start of the formal demonstration phase. Verification of corrections shall be made by the observer team.

4.5 Formal demonstration phase - During this phase, maintainability demonstration tests are performed, data acquired and analyzed. Also, the checklist is used to evaluate qualitative design features.

4.5.1 Qualitative

4.5.1.1 The number of items to be assessed shall be as specified in paragraph 5.1.2.

4.5.1.2 Assessment of each item shall be in accordance with paragraph 5.3.2.

4.5.1.3 Data collection shall be in accordance with paragraph 6.1.2.

4.5.1.4 Rejection/acceptance of an item shall be in accordance with paragraph 6.2.4.

4.5.1.5 Rejected items shall be retested during the Retest Phase in accordance with paragraph 4.6.

4.5.2 Quantitative

4.5.2.1 Sample size of tasks to be demonstrated shall be determined in accordance with paragraph 5.1. Additional items to be demonstrated shall be those selected by the contractor or procuring activity. Items selected by contractor shall be approved by the procuring activity.

4.5.2.2 Selection of each task shall be in accordance with paragraph 5.2.

4.5.2.3 Test of each task shall be in accordance with paragraph 5.3.1.

4.5.2.4 Data collection shall be in accordance with paragraph 6.1.2.

4.5.2.5 Data reduction and analysis shall be in accordance with paragraph 6.2.1.

4.5.2.6 All tasks rejected shall be retested during the Retest Phase in accordance with paragraph 4.6.

4.6 Retest Phase - During this phase, all rejected items and tasks are, after correction of deficiencies, retested.

4.6.1 Items failing to meet the acceptance criteria during the formal demonstration phase shall be retested during this phase after the contractor has corrected the deficiencies of the rejected items.

4.6.2 This phase shall also be used for special investigations of deficient or trouble areas. Additional areas to be investigated shall be those selected by the contractor or procuring activity. Areas selected by the contractor shall be approved by the procuring activity.

4.6.2.1 A deficient area shall be defined as an item that lacks one or more maintainability design characteristics.

4.6.2.2 Trouble area shall be defined as one or more of the following:

(a) Items which the maintenance team had difficulty in detecting, locating, and/or isolating the malfunction.

(b) Items that from past experience proved to have a high failure rate.

(c) Items that have poor accessibility for servicing, inspection, replacement, and/or repair.

(d) Items that from past experience proved difficult to trouble-shoot.

4.7 Sample Size Requirements

4.7.1 The procedure for determining corrective maintenance and preventive maintenance sample size shall be in accordance with paragraph 5.1.

4.7.2 Sample size shall be not less than fifty (50) for the corrective maintenance tasks and fifty (50) for the preventive maintenance tasks.

4.7.3 The contractor may elect to demonstrate all preventive maintenance tasks when approved by the procuring activity.

4.7.4 Corrective and preventive maintenance tasks which require unique skills, equipment, test methods, etc., shall be demonstrated in addition to the required sample size. Selection of these peculiar tasks shall be made by the procuring activity; however, the contractor may recommend tasks to be included.

4.8 Data Requirements

4.8.1 The contractor shall establish a maintainability data collection system for evaluation of maintainability demonstration results. This data system shall be compatible with and capable of accepting data from existing data systems in use by the Army.

4.8.2 Data collection shall be integrated as much as possible with similar data collection requirements such as reliability, human factors, etc., in order to provide accurate analysis.

4.8.3 Data collection formats and reports shall be in accordance with paragraph 6.

4.9 Contractor Organization and Maintainability Demonstration Schedule

4.9.1 The contractor shall prepare a detailed schedule of events occurring during the maintainability demonstration phases. This schedule shall include as a minimum the following:

(a) Pre-demonstration phase events

(b) Formal demonstration events

(c) Provisional events for the retest phase

4.9.2 In addition, an organization chart shall be prepared showing levels of authority and assigned responsibilities of personnel during the maintainability demonstration phase.

4.9.3 The organization chart and maintainability demonstration schedule shall be submitted to the procuring activity at least fifteen (15) days before start of predemonstration phase.

4.9.4 The maintainability schedule shall be updated and submitted at least fifteen (15) days before start of next phase.

5. TEST DEMONSTRATION PROCEDURE

5.1 Sample Size Calculation

5.1.1 The following procedure shall be the method used to determine the size of sample for corrective maintenance tasks (N_c), and the size of sample for preventive maintenance (PM) tasks (N_p).

(a) The following values shall be used to initially estimate sample sizes:

$K_\epsilon = 2.0$

$\bar{X} = 0.5$

$B = 0.75$

$S = 2.0$

(b) Estimate the sample size required from the following equation:

$$N_p \text{ or } N_c = \left(\frac{K_\epsilon \, S}{B \, \bar{X}}\right)^2$$

N_p = sample size of preventive maintenance tasks

N_c = sample size of corrective maintenance tasks

K_ϵ = confidence level coefficient (that the sample will give the true mean active maintenance down time)

B = Range or accuracy of the true mean

S = standard deviation of maintenance down time being sampled

$\bar{X}$ = mean of sample maintenance down time

(c) The number of corrective maintenance tasks for each category to be demonstrated shall be determined by multiplying the percent contribution of each category by the computed sample size, rounding off fractional numbers to the next larger integer.

(d) If the ratio of $\frac{S}{\bar{X}}$ as determined from the first twenty-five (25) test data points is different from the value assumed for this ratio in the initial determination of sample size, recompute the ratio of $\frac{S}{\bar{X}}$ based on these twenty-five (25) test data points and adjust the sample size to achieve the desired confidence level and accuracy.

(e) Repeat paragraph 5.1(d) for the first fifty (50) test data points.

5.1.2 Sample size for assessment of qualitative features shall be specified by the procuring activity.

5.2 Maintenance Task Selection

5.2.1 The number of corrective maintenance items to be used in the demonstration shall constitute a representative sample of the total population of corrective maintenance items and shall be determined in accordance with the following procedure: (Refer to Table 1 for an example.)

TABLE 1

CORRECTIVE MAINTENANCE SAMPLE SELECTION

A	B	C	D	E	F
Item	Failure/item 1000 hours (λ)	Quantity of each item (M)	Failures per 10^6 hours (λM)	Item % contributions to total maint task	Column E Regroup
CAE Installation					
CAE Engine	189.00	1	189.00		10.26
Crankcase Assy	27.00	1	27.00	14.30	
Cylinder Assy	0.50	12	6.00	3.17	
Crankcase & Assy	3.00	1	3.00	1.58	
.	.	.	.	.	
.	.	.	.	.	
.	.	.	.	.	
Cooling Fans	2.50	2	5.00	2.65	
Supercharger	1.50	2	3.00	1.58	
.	.				
.					
.					
Cooling System	44.287	1	44.287		2.78
Tube	0.224	9	2.016	4.540	
Seal	0.500	33	16.500	37.300	
Screw	0.100	94	9.400	21.200	
.	.	.	.	.	
.	.	.	.	.	
.	.	.	.	.	

TABLE 1 (Cont'd)

CORRECTIVE MAINTENANCE SAMPLE SELECTION

A	B	C	D	E	F
Item	Failure/item 1000 hours (λ)	Quantity of each item (M)	Failures per 10^6 hours (λM)	Item % contributions to total maint task	Column E Regroup
Blocks	0.001	40	0.040	0.040	
Gasket, Grommets	0.020	12	0.240	0.540	
Fire Extinquisher Detection Sys Sensors Amplifier Warning Light Wiring Connectors	24.055	1	24.055		1.40
Extinquishing Sys Time Delay Relay 1 Time Delay Relay 2 . . .	42.076	1	42.076		2.31

(a) In column A list and categorize all items (parts, modules, assemblies, etc.) in accordance with the maintenance concept employed and level of maintenance to be demonstrated.

(b) In column B list the failures/item 10^6 operational hours for each replaceable item, using reliability techniques and data sources approved by the procuring activity. For items that have no failure rate data available, the contractor shall use data developed from associated reliability programs or as determined by application of acceptable subjective estimation techniques. The source of the failure rate data shall be approved by the procuring activity prior to use.

(c) In column C determine the quantity of each item.

(d) In column D determine the total failures per 10^6 operational hours for each item.

(e) In column E determine the percent contribution of each item to the total corrective maintenance tasks.

(f) In column F group the items within the same category. Grouping shall be as specified by procuring activity. Assign a percent contribution equal to the sum of the individual percent contribution for these items.

(g) Apportion the number of corrective maintenance

tasks to be demonstrated in proportion to the item percent contribution to the total maintenance tasks.

(h) Specific tasks to be demonstrated shall be selected by the procuring activity in accordance with paragraph 4.7.4. Selection shall be accomplished by randomly selecting items within a category or type to which percentages have been allocated. Random numbers shall be used to accomplish the selection unless otherwise specified by the procuring activity.

(i) Each task will be demonstrated only once, unless otherwise specified by the procuring activity.

5.2.2 The number of preventive maintenance tasks to be used in the demonstration shall constitute a representative sample of the total population of preventive tasks and shall be determined in accordance with the following procedure: (Refer to Table 2 for an example.)

(a) List in column A all PM tasks required.

(b) In column B determine the frequency of occurrence for each PM task.

(c) In column C determine the percentage contribution of each sub-system to the system down time.

(d) Calculate the number of PM tasks to be simulated for each sub-system by multiplying the percentage contribution of that sub-system by the total number of PM tasks.

(e) Actual selection of specific PM tasks to be demonstrated to satisfy (d) above shall be accomplished by means of a table of random numbers, wherein each PM task in each sub-system shall be identified and random selection technique shall be used.

(f) Column D determines or estimates the active PM down time to accomplish each PM task by application of acceptable subjective estimation techniques.

5.2.3 The number of items to be used in assessment of

TABLE 2

PREVENTIVE MAINTENANCE SAMPLE SELECTION

A Preventive Maintenance Task	B Frequency per 600 hrs	C Item Percent Contribution to Total Maintenance Tasks	D Specified Active PM
CAE Engine	4	0.04	57 min
Transmission	2	0.02	30 min
Fuel System	1	0.01	15 min
Air Cleaners (2)	13	0.13	15 min
Gun/Turret Drive	8	0.08	10 min
.	.	.	.
.	.	.	.
.	.	.	.
Turret Slip Ring	6	0.06	15 min

qualitative features shall constitute a representative sample of the system and shall be determined in accordance with the following procedure: (Refer to Table 3 for an example.)

(a) List all items as shown in Table 3 by sub-system.

(b) For each sub-system check applicable qualitative area to the particular sub-system as shown in Table 3.

5.2.3.1 A table similar to Table 3 shall be submitted to procuring activity thirty (30) days prior to start of formal demonstration phase for review and approval. Selection of items to be assessed shall be selected by the procuring activity.

TABLE 3

QUALITATIVE APPORTIONMENT SAMPLE SELECTION

	Identification	Test Equipment	Equipment Unit	Visual Displays	and Illumination	Cabling & Connectors	Accessibility	Test Points	Servicing	Safety
NWL Suspension System and U S Track										
NWL H.S.A.	X		X				X	X		
Road Wheel Army Assembly		X			X		X			
Compensating Idler Arm					X			X		
Track Adjuster Assembly					X				X	
Track Assembly					X				X	
Sprockets					X					
Control & Display	X				X					
CAE Installation			X							
CAE Engine										
Cooling System		X	X		X	X	X	X		
Turret							X			
Hydraulic PS										
Gun/Turret Drive			X		X		X			
Gunner's Station	X	X	X	X	X	X	X	X	X	
Gunner's Primary Sight				X						
Gunner's Display/Controls	X			X						
Missile Xmitter Drive				X		X	X			
.										
.										
.										
Central Equipment										
Ballistic Computer System						X	X	X		

5.3 Test Method

5.3.1 The test procedure for verification of quantitative requirements (both corrective and preventive maintenance tasks) shall be as follows:

(a) Corrective Maintenance Items

1. Select task to be demonstrated in accordance with paragraph 5.2. Prepare task data sheet in accordance with paragraph 6.1.2(a).
2. Insert fault with the maintenance team absent from the area and in accordance with paragraph 5.2.1.
3. After fault is inserted and verified, alert and instruct the maintenance team in the manner usually employed to initiate maintenance action.
4. Collect and record required data in accordance with paragraph 6.1.2(b).
5. Repeat paragraph 5.3.1(a)1 thru 4 until all corrective maintenance tasks selected per paragraph 5.2 have been demonstrated.

(b) Preventive Maintenance Tasks

1. Select task to be demonstrated in accordance with paragraph 5.2. Then prepare task data sheet in accordance with paragraph 6.1.2(a).
2. Have maintenance team perform the preventive maintenance in accordance with the prescribed

procedure for the task.

3. Collect and record required data in accordance with paragraph 6.1.2(b).

4. Repeat 5.3.1(b)1 thru 3 until all preventive maintenance tasks selected per paragraph 5.2 have been demonstrated.

5.3.2 The test procedure for assessment of qualitative features shall be as follows:

(a) Select item to be assessed in accordance with paragraph 5.2.3.1.

(b) Prepare checklist data sheet in accordance with paragraph 6.1.2(d) and attach to checklist to be used for assessment of the selected item.

(c) Perform assessment of the selected item. Assessment shall be accomplished by the member(s) of the observer team qualified to assess the item. Each question, including those which are not applicable, shall be appropriately marked and initialed by the member(s) performing the assessment.

(d) Repeat paragraph 5.3.2(a) thru (c) until all selected items have been assessed.

5.4 Demonstration Criteria - The following criteria shall be adhered to in the demonstration of maintainability for the MBT-70 system.

5.4.1 The demonstration of quantitative tasks and evaluation of qualitative features shall be monitored and assessed under direction of the observer team.

5.4.2 Maintenance team shall meet the requirements of paragraph 4.2.2.

5.4.3 Data collection data, reduction data, analysis, and maintainability reports shall be in accordance with paragraph 6.

5.4.4 Any changes or deviations from requirements or procedures specified herein shall be approved by the procuring activity.

5.4.5 Corrective and preventive maintenance times shall be recorded to the nearest tenth minute.

5.4.6 A corrective maintenance task shall be terminated at three times the specified mean corrective time ($3\overline{M}_{ct}$) or when agreed that the maintenance team is unable to determine the failure. This task shall be assigned a time of three times the specified mean corrective time, noted and recorded.

5.4.7 Under the following conditions, man-hours may be excluded from the calculations for determining acceptance or rejection of the corrective and preventive maintenance tasks. All man-hours excluded shall

be noted and recorded.

(a) Man-hours expended due to technical manual inadequacies, subsequently corrected and proven to preclude recurrence of the problem.

(b) Man-hours required to repair an item for which an easier repair procedure or design change has been developed and approved by the procuring activity.

(c) Man-hours resulting from faulty test equipment.

(d) Man-hours expended on another fault occuring during time the pre-selected fault was inserted. The procuring activity may at its option elect to count the fault as another task.

(e) Man-hours expended due to an unavoidable accident or mishandling.

(f) Man-hours expended due to improper insertion of pre-selected fault.

(g) Under paragraphs c, d and f the procuring activity may at its option elect to count the fault as another task.

6. Data

6.1 Reports and Data Collection

6.1.1 Reports - The following reports shall be included as part of the data submitted to the procuring activity for review and approval:

(a) Information to be contained in each observer and maintenance team biography report shall be as outlined in Figure 6.1.

(b) The pre-demonstration phase report shall describe in detail results of the pre-demonstration phase evaluation. All deficiencies and the steps taken to correct these deficiencies shall be contained in the report. Potential problems that may occur during formal demonstration shall be included.

6.1.2 Collection of data shall be as follows:

(a) A task data sheet shall be prepared for each task as outlined in Figure 6.2 and in accordance with paragraphs 4.1.8 and 4.3.4.

(b) Corrective and preventive maintenance data shall be recorded on the failure data sheet shown in Figure 6.3 and in accordance with paragraph 5.3.1(a)4.

(c) The task data sheet shall be attached to the failure data sheet.

(d) A separate checklist data shown in Figure 6.4

Sheet __of __

BIOGRAPHIC DATA (OBSERVER)

NAME_____

JOB TITLE (PRESENT)_____

EXPERIENCE (BY DATE) Only include experience applicable to area of responsibility on observer team.

PROCURING ACTIVITY APPROVAL_____

Figure 6.1a Biographic Data Form for Observer Team

Sheet__of__

BIOGRAPHIC DATA (MAINTENANCE)

NAME_____

JOB TITLE (PRESENT)_____

ORGANIZATION_____

SCHOOLING (BY DATE) Include only schooling related to job position._____

_____

_____

EXPERIENCE (BY DATE) Only include experience related to system under test._____

_____

_____

_____

_____

_____

_____

PROCURING ACTIVITY APPROVAL_____

Figure 6.1b Biographic Data Form for Maintenance Team

Sheet__of__

TASK DATA SHEET

TASK_____ TASK NO_____

TEST CONDITIONS

1. Maintenance Environmental Conditions per paragraph 4.1.5.
2. Level of Maintenance per paragraph 4.1.4
3. Mode and configuration of task under test per paragraph 4.1.8.
4. Type of failure simulated per paragraph 5.2.1
5. Special conditions such as special or peculiar support material required, unusual test site conditions and facilities requirements, or any unusual conditions and requirements which the task is to be demonstrated under. Also, all deviations and changes shall be noted here.

Figure 6.2 Task Data Sheet Form

Sheet__of__

FAILURE DATA SHEET

DATE_____ TASK NO_____

OBSERVERS_____

_____

_____

MAINTENANCE TEAM_____

LOCATION

SUBSYSTEM_____ # _____

CHASSIS NAME_____ # _____

PANEL NAME_____ # _____

PART NAME_____ # _____

CIRCUIT BOARD NAME

_____ # _____

FAILURE SIMULATION

TYPE OF FAILURE SIMULATED_____

METHOD OF SIMULATION_____

SYMPTIONS OF FAULT INSERTION_____

MODE OF OPERATION AT DETECTION_____

Figure 6.3 Failure Data Sheet Form

Sheet__of__

FAILURE DATA SHEET (CONT'D)

COMMENTS

ADMINISTRATIVE

TIME RECORD

OUT___
IN___
OUT___
IN___
OUT___
IN___
OUT___
IN___
OUT1345
IN 1358
OUT___
IN___
OUT___
IN___
OUT___
IN___
OUT___

Narrative of maintenance team activities. Time is to be continuous and is to include all coffee breaks, lunch periods, rest breaks, etc.

EXAMPLE:

1300 Start
1301 Verify symptoms
1305 Study schematics
1315 Remove cover and pull drawer out
1318 Use scope to trace signal
1345 Coffee break
1358 Back on job
1406 Traced trouble to correct circuit
1413 Used VTVM to locate faulty component
1506 Administrative time (obtain part)
1516 Remove faulty part and replace with good one
1521 Closed unit. Test complete

Sheet__of__

FAILURE DATA SHEET (CONT'D)

TIME DATA

START OF EXERCISE_____ TIME FOR EACH ELEMENT_____

DETECTION_____ _____

LOCALIZATION_____ _____

ISOLATION_____ _____

REPAIR_____ _____

CHECKOUT_____ _____

Sheet__of__

QUALITATIVE CHECKLIST DATA SHEET

TASK_____ TASK NO_____

LOCATION_____

OBSERVERS_____

_____

_____

_____

_____

QUALITATIVE FEATURES REJECTED

QUESTION NO	
_____	Reasons for rejection per paragraph 6.2.4(b)
	_____
_____	_____
	_____
	_____
_____	_____
	_____
	_____

Figure 6.4 Qualitative Checklist Data Sheet Form

shall be prepared for each checklist used to evaluate the item. These checklist data sheets shall then be attached to the checklists used to evaluate that particular item.

6.2 Data Reduction and Analysis (See Appendix C for further explanation of formulas.)

6.2.1 The quantitative data obtained from the formal demonstration phase shall be reduced and analyzed as follows to determine acceptance or rejection of $\overline{M}_{ct}$ and $\overline{M}_{pt}$ for each task:

(a) The raw data derived from corrective maintenance test shall be screened thoroughly to ensure pertinent simulation and measurement requirements have been achieved, and any ambiguities in the test record resolved.

(b) To determine acceptance or rejection of the corrective maintenance tasks against the mean corrective time (M_{ct}) specified in paragraph 4.1.2(a), the following criteria shall apply. Accept the tasks if the

$$M_{ct}\ (\text{specified}) \geq \overline{M}_{ct} + \frac{K_{\epsilon}\ S_{\overline{M}_{ct}}}{\sqrt{n_c}}$$

otherwise reject the tasks.

(c) To determine acceptance or rejection of the preventive maintenance tasks against the mean

preventive maintenance time ($\overline{M}_{pt}$) specified in paragraph 4.1.2(a), the following criteria shall apply. Accept the tasks if the

$$M_{pt} \text{ (specified)} \geq \overline{M} + \frac{K_\epsilon \; S\overline{M}_{pt}}{\sqrt{N_p}}$$

otherwise reject the tasks.

6.2.2 The quantitative data obtained from the formal demonstration phase shall be reduced and analyzed to determine acceptance or rejection of total system mean down time ($\overline{M}$) as follows:

(a) Perform paragraph 6.2.1(a) through 6.2.1(c).

(b) To determine acceptance or rejection of all the tasks against the specified mean down time (M) for the system, the following criteria shall apply. Accept the tasks if the

$$M \text{ (specified)} \geq \overline{M} + K_\epsilon \sqrt{\frac{N_p (f_c \; S\overline{M}_{ct})^2 + N_c (f_p \; S\overline{M}_{pt})^2}{(N_p)(N_c)(f_c + f_p)^2}}$$

otherwise reject the tasks.

6.2.3 The quantitative data obtained from the formal demonstration phase shall be reduced and analyzed to determine the frequency and cumulative frequency distribution as follows:

(a) List the time required to complete each task and the times required for detection, localization,

isolation, repair and checkout.

(b) Order the total times for the tasks and obtain frequency and cumulative frequency distributions for corrective maintenance tasks, preventive maintenance tasks, detection time, localization time, isolation time, repair time and checkout time.

(c) A histogram chart for each of items listed in b above shall be submitted to the procuring activity for review and approval.

6.2.4 The qualitative data obtained from the formal demonstration phase shall be reduced and analyzed to determine acceptance or rejection of an item as follows:

(a) The raw data derived from the checklist shall be screened thoroughly to ensure that any ambiguities in the record data are resolved.

(b) Acceptance or rejection of an item assessed shall be determined by the observer team. Determination of whether to accept or reject the item shall be based on at least the following:

1. Safety hazard to operating and maintenance personnel.
2. Criticality of the item for a mission.
3. Cost, time and resources required to correct deficiencies of the item.

4. Improvement in corrective or preventive maintenance times that could be realized.

(c) An item rejected shall be justified by documental evidence and shall be signed by observer team members performing the analysis.

(d) Deficiencies in the rejected items shall be corrected and these shall then be submitted for revaluation during the Retest Phase.

6.3 Maintainability Demonstration Report

A final maintainability demonstration report shall be submitted to the procuring activity within thirty (30) days after completion of the formal demonstration phase. The final report shall contain the following sections as a minimum:

(a) Data collected

(b) Factors which influence the data

(c) Analysis of the data

(d) Results of the demonstration

(e) Assessment of qualitative factors

(f) Deficiencies

(g) Recommendations

1. To correct deficiencies

2. For suggested improvements

(h) Results of retest

APPENDIX A

7. Qualitative Checklist - The checklist is composed of yes-no questions. These questions shall be answered; either the item has the feature or the item does not have the feature in question or the question is not applicable. Each question shall be initialed by the observer team member(s) answering the question and all questions shall be answered. A checklist is considered to be a major heading. For example, questions associated with accessibility is considered one checklist and test points is another checklist. The checklists are:

   (a) Accessibility
   (b) Cabling and Connectors
   (c) Identification
   (d) Safety
   (e) Visual Displays and Illumination
   (f) Servicing
   (g) Test Points
   (h) Test Equipment
   (i) Equipment Units

   A qualitative checklist data sheet form shall be attached to each checklist used in assessment of an item.

ACCESSIBILITY

	Yes	No	NA	Initial
1. Is access to the item obstructed such that no other equipment must be removed to gain access or accomplish removal?				
2. Are access openings free of sharp edges or projections which could injure the technician or snag clothings?				
3. Are accesses labeled to specify the frequency for maintenance, either by calendar or operating time?				
4. Are accesses labeled to indicate what auxiliary equipment is needed for service, checking, etc., at this point?				
5. Are accesses labeled to indicate what can be reached through this point (label on cover or close thereto)?				
6. Are access points individually labeled so they can be easily identified with nomenclature in the job instructions and maintenance manuals?				

	Yes	No	NA	Initial
7. Are parts which require access from two or more openings marked to so indicate in order to avoid delay and/or damage by trying to repair or remove through only one access?				
8. Are heavy units (more than 25 Lbs) installed within normal reach of a technician for purposes of replacement?				
9. Are access doors made in whatever shape is necessary to permit passage of components and implements which must pass through?				
10. If the maintenance technician must be able to see what he is doing inside the equipment, does the access provide enough room for the technician's hands or arms and still provide an adequate view of what he is to do?				
11. Are units laid out so maintenance technicians are not required to retrace their movement during equipment checking?				

	Yes	No	NA	Initial
12. Can adjustment type controls be adjusted with the adjustment tool clear of any obstruction?	—	—	—	———
13. Is equipment designed so that it is not necessary to remove any assembly from a major component to troubleshoot that assembly?	—	—	—	———
14. Are components places so that all throwaway assemblies or parts are accessible without removal of other components?	—	—	—	———
15. Are components placed so that there is sufficient space to use test probes, soldering irons, and other required tools without difficulty?	—	—	—	———
16. If a screw-access plate is used, are no more than 4 captive quick-opening screws used?	—	—	—	———
17. Are units which are frequently pulled out of their installed position for checking mounted on rollout racks, slides, or hinges?	—	—	—	———

	Yes	No	NA	Initial
18. Is the equipment easily removed and replaced by one man?	—	—	—	———
19. Are access covers, which are not completely removable, self-supporting in the open position?	—	—	—	———

CABLING AND CONNECTORS CHECKLIST

Cables

	Yes	No	NA	Initial
1. Are the cables sufficient length so that each functioning unit can be checked in a convenient place?	—	—	—	———
2. Are cables routed so they need not be bent or unbent sharply when being connected or disconnected?	—	—	—	———
3. Are cables directly accessible to the technician wherever possible (not under panels or floor boards which are difficult to remove)?	—	—	—	———
4. Are cables routed so they cannot be pinched by doors, lids, etc., or so they will not be stepped on or used as hand holds by maintenance or operating personnel?	—	—	—	———
5. Is electrical wiring routed away from all lines that carry flammable material?	—	—	—	———

	Yes	No	NA	Initial
6. Is direct routing through congested areas avoided wherever possible?	—	—	—	———
7. Are all cables color coded and both ends tagged? Are colors selected which cannot be confused because they are too nearly alike or may not be recognized because of poor illumination?	—	—	—	———
8. Has care been taken in design of cable conduits to prevent collection of water or debris which could interfere with operation of a control system (freezing or short circuiting)?	—	—	—	———
9. Have the connections been designed to prevent interchanging of cables?	—	—	—	———
Connectors				
1. Are connector plugs designed so that pins cannot be damaged (aligning pins extended beyond electrical pins)?	—	—	—	———

	Yes	No	NA	Initial
2. Are electrical connectors protected from possible shorting through contacts with external objects? Are adequate covers provided on electrical connectors to prevent foreign matter from shorting out the connectors?				
3. Are separate ground connections provided for each voltage regulator so that a single grounding failure does not cause failure of several other systems?				
4. Do markings on plugs, connectors, and receptacles show proper position of keys for aligning pins for proper insertion position?				
5. On cable connected removable units, will plug and receptacle disconnect before cable breaks?				
6. Are u-slugs (spade) used in lieu of O-slugs (ring) where frequent removals are anticipated?				

	Yes	No	NA	Initial
7. Are connectors accessible for easy replacement or repair?	—	—	—	———
8. Have quick disconnect devices been used where possible to save time and minimize human error which could occur in soldering, etc.?	—	—	—	———
9. Is there sufficient space between connectors so they can be grasped firmly for connecting and disconnecting in all maintenance environments? For example, extra clearance for gloves.	—	—	—	———

IDENTIFICATION

	Yes	No	NA	Initial
1. On equipment utilizing color coding, is meaning of colors given in manuals and on an equipment panel?	—	—	—	———
2. Is color coding consistent throughout system, equipment, and maintenance support?	—	—	—	———
3. Do display and control labels clearly indicate their functional relationship? Are displays labeled by functional quantity rather than operational characteristics (i.e., gal, psi, ohms, etc.)?	—	—	—	———
4. Are display labels imprined, embossed, or attached in such a way they will not be lost, mutilated, or become otherwise unreadable?	—	—	—	———
5. Are displays labeled so they correlate with notations found in system diagrams, in technician manuals or related literature?	—	—	—	———

	Yes	No	NA	Initial
6. Are lubrication points properly labeled?	—	—	—	———
7. Are schametics and instructions attached directly to, or adjacent to chassis for all units which may require troubleshooting?	—	—	—	———
8. Is the unit labeled and, if possible, with full identifying data?	—	—	—	———

SAFETY

	Yes	No	NA	Initial
1. Are fire extinguishers placed where they are readily accessible, but not immediately adjacent to points where fire would probably originate?	—	—	—	———
2. Are critical warning lights isolated from other less important lights for best effectiveness?	—	—	—	———
3. Is a transparent window or removable cover installed over fuses so they can be checked without removing the entire component case?	—	—	—	———
4. Are safety interlocks used wherever necessary?	—	—	—	———
5. Are warning lights provided to indicate fire or excessive heat in areas not visible to the driver?	—	—	—	———
6. Are jacking and hoisting points clearly, conspicuously, and unambiguously identified?	—	—	—	———

	Yes	No	NA	Initial
7. Are color code techniques utilized which define operating and danger ranges to simplify check reading?	—	—	—	———
8. Are components located and mounted so that access may be achieved without danger to personnel from electrical charge, sharp edges and points, moving parts, and chemical contamination?	—	—	—	———
9. Are on-off or fail-safe circuits utilized wherever possible to minimize failures without operator knowledge?	—	—	—	———
10. Are safety guards provided for all potential personnel hazards such as engine inlets, exhaust pipes, ordnance devices, pneumatic and hydraulic devices and lines, oxygen and fuel containers and lines, etc.?	—	—	—	———

VISUAL DISPLAYS AND ILLUMINATION

	Yes	No	NA	Initial
1. Do the displays contain only information that is absolutely necessary to make a good decision?	—	—	—	———
2. Are the displays coded so both the correct reading and tolerance limits are easily identifiable?	—	—	—	———
3. Are the displays on the same panel surface as their related control?	—	—	—	———
4. Are the displays oriented normal to the observer's line of sight to avoid parallax reading errors?	—	—	—	———
5. Have the visual displays been kept as simple as possible within informational requirements?	—	—	—	———
6. Are numerals on fixed visual displays mounted so they do not have to be read upside down?	—	—	—	———

	Yes	No	NA	Initial
7. Have displays of a go-no-go type been used where possible?				
8. Have non-glossy surfaces or highly polished metals been eliminated?				
9. Are the visual indicators easy to read and see, when operator is in his normal operating position?				
10. Are the maintenance displays hidden from the operator when not needed for normal operator duties?				
11. Is there enough contrast between the color of dial and scale markings and the background of the dial?				
12. Are the displays arranged by function and emphasized by color coding, outline borders, etc.?				
13. Is the vibration of visual displays enough to cause inaccurate readings of displays?				

	Yes	No	NA	Initial
14. Has the following consideration been included for good illumination?				
a. Suitable brightness for task at hand.				
b. Uniform lighting on the task.				
c. Suitable contrast between task and background.				
d. Freedom from glare from either the light source or the work surfaces.				
e. Suitable quality and color for the illumination and surfaces.				
15. Has adequate supplementary lighting been provided for performance of maintenance?				
16. Are lamps for pilot lights and other displays easily removable from the frame of panel?				

SERVICING CHECKLIST

	Yes	No	NA	Initial
1. Are adequate lubrication instructions provided for identifying the frequency and type of lubricants required?				
2. Are drains provided on all fluid tanks and systems, fluid filled cases or pans, filter systems, float chambers, and other items designed to contain fluid that would otherwise be difficult to remove?				
3. Are drain points located at the lowest point when complete drainage is required or when separation of fluids is desired? (as when water is drained out of fuel tanks)				
4. Are drain points placed where they are readily operable by the technician?				

	Yes	No	NA	Initial
5. Are fuel tank filler necks, brake air cocks, flexible lines or cables, pipe runs, fragile components and like items positional so they are not likely to be used as convenient footholds or handholds, thereby sustaining damage?				
6. Are drain cocks or valves clearly labeled to indicate open and closed positions, and the direction of movement required to open?				
7. Are filler openings located where they are readily accessible and do not require special funnels?				

TEST POINTS CHECKLIST

	Yes	No	NA	Initial
1. Are test points located on front panel wherever possible?	—	—	—	———
2. Is accessibility of external test points assured under use conditions?	—	—	—	———
3. Are all test points color coded with distinctive colors?	—	—	—	———
4. Are test points provided in accordance with the system test plan?	—	—	—	———
5. Are test points located close to controls and displays with which they are associated?	—	—	—	———
6. Are test points located so technician operating associated control can read signal on display?	—	—	—	———
7. Are test points planned for compatibility with the maintenance skill level involved and not randomly located?	—	—	—	———

	Yes	No	NA	Initial
8. Are test points adequately illuminated?	—	—	—	_____
9. Are built-in test features provided wherever standard portable test equipment cannot be used?	—	—	—	_____
10. Are test points provided for direct check of all replaceable parts?	—	—	—	_____

TEST EQUIPMENT CHECKLIST

	Yes	No	NA	Initial
1. Are the instructions for using test equipment in step-by-step format?				
2. Do plugs, jacks and binding posts used for test of test equipment appear on outer casing of equipment so it is not necessary to remove the case? If internal repair requires removal of case, are duplicate jacks, plugs, etc., provided on chassis so jury-rig connections to the case are not necessary?				
3. Is test equipment designed so as to be capable of connection to prime equipment within two (2) minutes?				

	Yes	No	NA	Initial
4. Is adequate support provided for test equipment which must be taken into work area so the technician does not have to hold the test equipment or take separate support devices to the work area for this purpose?				

EQUIPMENT UNITS CHECKLIST

	Yes	No	NA	Initial
1. Are plug-in components used where feasible?	—	—	—	———
2. Is wrong installation of unit prevented by virtue of size, shape, configuration?	—	—	—	———
3. Are means provided for pulling drawers and slide-out racks without breaking electrical connections when internal in-service adjustments are required?	—	—	—	———
4. Are units and assemblies mounted so that replacing one does not require removal of others?	—	—	—	———
5. Are all replaceable parts accessible by fold-out construction or other special techniques when necessary?	—	—	—	———
6. Are parts, assemblies and components placed so there is sufficient space to use test probes, soldering irons, and other items?	—	—	—	———

	Yes	No	NA	Initial
7. Are all throwaway items made accessible without removal of other items?	—	—	—	———
8. Are guides used for module installation?	—	—	—	———
9. If method of opening a cover is not obvious, is an instruction plate attached to the outside of the cover?	—	—	—	———
10. Are handles or other suitable means for grasping, handling, or carrying provided on all units designed to be removed or replaced?	—	—	—	———
11. Are handles placed above the center of gravity and positioned for balanced loads?	—	—	—	———
12. Are handles provided on transit cases to facilitate handling and carrying of unit?	—	—	—	———

APPENDIX B

8. Quantitative Apportionment - The mean times shall be apportioned per paragraph 8.1. Times specified herein include time to localize, isolate, repair and check out the item. This time also includes the time required to gain access to the faulty item.

MEAN MAINTENANCE TIMES

	Scheduled	Corrective Maintenance	
		Unscheduled	Remove/Replace
	M_{pt}	M_{ct}	
8 MBT-70			
8.1 Chassis Development			
8.1.1 Hull			
8.1.1.1 Hull Common Items			
8.1.1.1.1 Hull Stowage	10MH		
2 Escape Hatch			
3 Radiological Shielding			
4 Fenders			
8.1.1.2 Hull for CAE Installation			
8.1.1.2.1 Hull Structure	5MH		
2 Grilles & Access Doors	10MH		
8.1.2 Suspension			
8.1.2.1 Suspension Common Items	10MH		
8.1.2.1.1 Compensating Idler Hubs		0.45 m hr	
2 Support Roller Assemblies	5MH	1.80 m hr	
3 Roadwheel Hubs		0.90 m hr	
4 Roadwheels	5MH	0.45 m hr	
5 Compensating Idler Wheels		0.45 m hr	
8.1.2.2 NWL Suspension System & US Track			
8.1.2.2.1 NWL H.S.A.	86MH	1.80 m hr	12.30 m hr
2 Roadwheel Army Assembly	None	0.02 m hr	2.00 m hr
3 Compensating Idler Army Assembly	2MH	0.34 m hr	2.00 m hr
4 Track Adjuster Assembly	20MH	.05 m hr	1.00 m hr
5 Bump Stops	NA	NA	NA
6 Track Assembly	16MH	9.00 m hr	54.5 m hr
7 Sprockets	5MH	0.069 m hr	0.83 m hr
8 Controls/Displays	NA	0.45 m hr	NA

	Scheduled	Corrective Maintenance Unscheduled	Remove/Replace
	M_{pt}	M_{ct}	
8.1.3 Power Train			
8.1.3.1 Power Train Common Items			
8.1.3.1.1 Final Drive		0.45 m hr	
2 Sprocket Hub		5.00 m hr	
3 Braker	5MM		
4 Engine/Transmission Coupling			
5 Accessory Drives	5MM		
6 Oil Cooled Braker			
8.1.3.2 CAE Installation			
8.1.3.2.1 CAE Engine	3 m hr	12.0 m hr	
2 Transmission	0.5 m hr	1.8 m hr	
3 Fuel System	0.25 m hr	4.5 m hr	
4 Induction System	5MM		
5 Exhaust System	5MM		
6 Power Train Mounting & Removal			
7 Cooling System		NA	NA
8 Air Cleaners	0.25 m hr	NA	
8.1.4 Automotive Elect			
8.1.4.1 Generating System		3.6 m hr	
8.1.4.1.1 Rectifier	1MM		
2 Alternator	4MM		
3 Voltage Regulator			
8.1.4.2 Remote Controls		0.45 m hr	
3 Driving Lights	2MM	0.45 m hr	
4 Wiring		0.90 m hr	
5 Generating System Installation			
8.2 Turret Assembly Development			
8.2.1 Weapon Mounts			

	Scheduled	Corrective Maintenance	
		Unscheduled	Remove/Replace
	M_{pt}	M_{ct}	
8.2.1.1 Crd's Weapon Mount	10MM		
2 Mounts for Grenade Launcher	5MM		
3 Primary Weapon Mount	15MM	0.45 m hr	
8.2.1.2.1 Gun Shield			5.2 m hr
2 Recoil Mechanism and Buffer	5MM		44MM
3 M73 C Mount		2.70 m hr	3 m hr
4 Trunnion Assembly		0.45 m hr	31MM
8.2.2 Turret	5MM	0.45 m hr	56MM
8.2.2.1 Hydraulic Power Supply	2.5 m hr	0.102 m hr	1.83 m hr
2 Turret Structure	5MM		
3 Basket Assembly	5MM		
4 Turret Lock	1MM		
5 Hatches (Cmdr's & Gunners)	5MM	0.90 m hr	
6 Seats (Cmdr's & Gunners)	3MM		
7 Turret Stowage	5MM		
8 Radiological Shielding			
9 Bearing Assembly	5MM		
10 Automatic Loader & Controls	5MM	2.70 m hr	
11 Gun/Turret Drive System	10MM	2.70 m hr	
12 Electro-Hydr. Turret Slip Ring			
8.2.3 Driver's Station			
8.2.3.1 Driver's Rotable Capsule	5MM	0.90 m hr	
2 Driver's Visition	15MM	0.45 m hr	
3 Driving Controls	15MM		
4 Instrument Panel	5MM		
5 Electrical Slip Ring	10MM		
8.2.4 Commander's Station			
8.2.4.1 Cdr's Panoramic Sight	20MM	3.15 m hr	
2 Cdr's Night Sight	10MM	0.45 m hr	

	Scheduled	Corrective Maintenance	
		Unscheduled	Remove/Replace
	M_{pt}	M_{ct}	
3 Cdr's Display/Controls	4MM	0.45 m hr	
4 Cdr's Visition Blocks	5MM	0.45 m hr	
8.2.5 Gunner's Station			
8.2.5.1 Gunner's Primary Sight	23MM	111MM	
2 Gunner's Aux Sight	10MM	0.45 m hr	
3 Gunner's Night Sight	10MM	0.45 m hr	
4 Gunner's Displays/Controls	4MM	0.70MM	
5 Gunner's Vision Blocks	5MM	0.45 m hr	
6 Missile Transmitter Drive		2 m hr	
8.2.6 Central Equipment			
8.2.6.1 Ballistic Computer System		25MM	
2 Fire Control & Stab Electronics	20MM		
3 AC Power Supply		36MM	
4 Interconnect Cabling & Relays Cdr's Station			
5 Azimuth Indicator		0.45 m hr	
6 Audio Monitoring		0.45 m hr	
7 Television Sight		3.60 m hr	
8 Communication Equipment Installation	8 MM	0.45 m hr	
9 Interconnect Cabling and Relays Gunner's Station	NA	1.25 m hr	
8.2.7 Integration			
8.2.7.1 Fire Control Integration		1.80 m hr	
2 Turret and Weapon Integrating		0.483 m hr	1 m hr
8.2.8 Turret Electrical			
8.2.9 Fire Extinquisher System	0.4 m hr		

NOTE: m hr = man-hours

MM = man-minutes

APPENDIX C

9. Theory and Explanation of Sample Size, Corrective Maintenance and Preventive Maintenance Equations

9.1 Assumptions - The equations used to determine acceptance/rejection of a task and to determine sample size are based on the normal distribution. This is possible as the tasks are independent from each other, sample size is equal to or greater than fifty, and the properties of the 'Central-limit Theorem' can be used. The theorem states that if the random variable X is distributed with mean μ and variance σ^2 (but with density function unknown), then the distribution of the sample mean $\bar{X}$ is very closely approximated by the normal distribution with mean μ and variance σ^2 when n is large. For the application here, there is practically no difference as n is fifty or greater.

9.1.1 Under the assumptions stated above, sample size equation per paragraph 5.1 can be derived. The confidence interval for a normal distribution is defined as:

$$\mu - \bar{X} = \frac{K_\epsilon S}{\sqrt{n}}$$

where μ - true mean for an infinite sample

$\bar{X}$ - mean for a sample size of n

K_ϵ - confidence level coefficient

S - estimated standard deviation

n - sample size

By rearranging this equation and redefining $\mu - \bar{X}$, the equation used for calculation of sample size for preventive and corrective maintenance tasks is obtained. Steps taken to obtain this equation are:

$$n = \left(\frac{K_\epsilon \cdot S}{\mu - \bar{X}}\right)^2$$

Let $\mu - \bar{X} = B\bar{X}$ where B is defined as the range or accuracy desired.

Let $n = N_c = N_p$

Thus the desired equation is obtained

$$N_c \text{ or } N_p = \left(\frac{K_\epsilon \, S}{B\bar{X}}\right)^2$$

9.2 Corrective and Preventive Maintenance Formulas - Both the corrective and preventive maintenance acceptance/rejection formulas are based on the t-distribution. Since the sample size is restricted to values of fifty or greater, the value of K_ϵ is very close to the value of t_ϵ. A table of normal values is usually more readily available and therefore is used.

9.2.1 The corrective and preventive maintenance equations are defined as:

Corrective Maintenance Equation

$$M_{ct}\ (\text{Specified}) \geq \bar{M}_{ct} + \frac{t_\epsilon\ S\bar{M}_{ct}}{\sqrt{N_c}}$$

Preventive Maintenance Equation

$$M_{pt}\ (\text{Specified}) \geq \bar{M}_{pt} + \frac{t_\epsilon\ S\bar{M}_{ct}}{\sqrt{N_p}}$$

$\bar{M}_{ct}$, $\bar{M}_{pt}$ = Mean downtime of the sample

$t_\epsilon = K_\epsilon$ = Confidence level coefficient (percent of time that the sample will give the true mean downtime or is producer's risk)

$S\bar{M}_{ct}$, $S\bar{M}_{pt}$ = Standard deviation of sample

N_c, N_p = Sample size

9.2.2 The mean downtime for the total system is also obtained from the t-distribution. As the same assumptions hold, t_ϵ may be substituted by K_ϵ. The equation is defined as :

$$M \text{ (Specified)} \geq \bar{M} + t_{\epsilon} \sqrt{\frac{N_p \left(f_c \, S\bar{M}_{ct}\right)^2 + N_c \left(f_p \, S\bar{M}_{pt}\right)^2}{(N_p)(N_c)(f_c + f_p)^2}}$$

M = Specified mean downtime for the system

$\bar{M}$ = Total mean downtime as result of test demonstration

t_{ϵ} = Confidence level coefficient (percent of time that the sample of systems will give the true mean corrective downtime)

N_c = Number of tested corrective maintenance tasks

N_p = Number of tested preventive maintenance tasks

f_c = Number of expected corrective maintenance tasks occuring during a specified operating period

f_p = Number of expected preventive maintenance tasks occuring during a specified operating period

$S\bar{M}_{ct}$ = Standard deviation of corrective maintenance tasks for the total system

$S\bar{M}_{pt}$ = Standard deviation of preventive maintenance tasks for the total system